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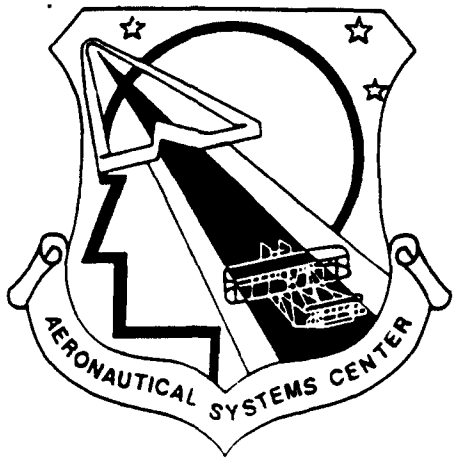
MODULAR SIMULATOR SYSTEM (MSS)

SYSTEM/SEGMENT SPECIFICATION FOR THE GENERIC MODULAR SIMULATOR SYSTEM - PHYSICAL CUES

MODULE VOLUME 10



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AUGUST 1993

FINAL REPORT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.

SYSTEMS ENGINEERING DIVISION
AERONAUTICAL SYSTEMS CENTER
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WRIGHT PATTERSON AFB OH 45433-7126

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This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*

This is the Physical Cues portion of the generic Modular Simulator System (MSS) specification. It is designed to be tailored to specify the requirements for a specific aircraft training device or family of aircraft training devices. This specification contains specific tailoring instructions for each paragraph. When the tailoring process is complete, the italicized tailoring instructions should have been replaced by application specific text or deleted from the specification. It is suggested that the user read the "Modular Simulator Engineering Guide" and the "Modular Simulator Management Guide" prior to tailoring this volume.

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PREFACE

This generic Modular Simulator System (MSS) segment specification has been developed in accordance with DI-CMAN-80008A, Data Item Description for System/Segment Specifications. This specification meets or exceeds the requirements for MIL-STD-490, Type A, specifications. This specification is designed to be tailored to specify the requirements for a specific aircraft training device or family of aircraft training devices. Training devices may consist of Weapons System Trainers (WST), Operational Flight Trainers (OFT), Cockpit Procedures Trainers (CPT), Part Task trainers (PTT), etc.

Tailoring will be necessary to meet specific application requirements. The tailoring must be accomplished so as not to violate the goals and intent of the MSS concept. It is assumed that the user of this document has a familiarity with the MSS design concepts and architecture, the application aircraft training requirements, and general working knowledge of aircraft training systems. It is suggested that the user read the "Modular Simulator System Engineering Design Guide (D495-10440-1) and the "Modular Simulator System Management Guide" (D495-10439-1 prior to tailoring this specification. These guides provide an overview of the MSS architecture, an in-depth discussion on its application, and lessons learned from previous applications.

Each segment in the MSS architecture provides a portion of the overall system functionality. Similar functions and operations were grouped in each segment based on past experience, areas of design expertise, and management of intersegment communication. To promote reuse of the segments and gain the maximum benefits of using the MSS approach, it is suggested that the user adhere to the generic functional allocation. Interfaces between the segments should remain relatively constant from application to application. The application vehicle is considered to be an aircraft (e.g. fixed wing, variable geometry, or rotary wing), although the MSS architecture and concepts may be applied to either ground or sea vehicles.

This specification contains specific tailoring instructions for each paragraph. The instructions are contained within the paragraphs, and are identified by blank spaces and/or italicized text. When the tailoring process is complete, the italicized tailoring instructions should have been replaced by application specific text or deleted from the specification. Paragraphs which do not apply to a particular application should not be deleted. They should be identified as "Not Applicable" to maintain paragraph numbering consistency between volumes and various MSS applications.

1. SCOPE

1.1 Identification. This segment specification volume establishes the requirements for the Physical Cues segment of the _____ *(insert application aircraft type)* Modular Simulator System (MSS). This volume is one of _____ *(insert number of volumes in the application system/segment specification)* volumes which comprise the system/segment specification for the_____ *(insert application aircraft type)* MSS. Volume I of this specification contains system level requirements such as MSS structure, communication architecture, network interface performance, system level diagnostic and test requirements, Ada programming language applicability, adaptability and expansibility, and other requirements which pertain to all volumes.

1.2 System Overview. The Physical Cues segment provides the simulation, stimulation, and/or emulation of the ownship physical cues functions within the _____*(insert application aircraft type)* MSS. The Physical Cues segment provides for the simulation of the environmental sound, G-suit, G-seat, motion geometry, motion cue, motion base, vibration and buffet and support functions throughout the flight envelope of the ownship. The physical cues model is based on flight test data, and derived data for the _____*(insert application aircraft type)*. The Physical Cues segment interfaces with the other MSS segments as described in the _____ *(insert application aircraft type)* MSS Interface Design Document (IDD)_____ *(insert IDD document number)*. Each of the Physical Cues segment functions identified are processed within the Physical Cues segment.

The function of the Physical Cues Segment is to provide real-time physical cues to induce physical sensations intended to lead to a trainee perception that the _____ *(insert application aircraft type)* MSS is operating and moving within an environment. This segment is responsible for all audio cues except warning tones and communication/navigation tones and all motion cues. This segment does not address visual cues.

The Physical Cues Segment interfaces with several other _____ *(insert application aircraft type)* MSS segments, but primarily with the Instructor/Operator Station and Flight Dynamics segments.

The environmental sound function processes information about the _____ *(insert application aircraft type)* MSS movement and environment to produce audio cues for both internal (e.g. landing gear) and external (e.g. weather) sounds. The motion function and g-suit/g-seat functions also processes information about the _____ *(insert application aircraft type)* MSS movement and environment to produce motion/G cues representing the current flight situation.

These functions may require the use of actual _____*(insert application aircraft type)* equipment such as the pilot's seat or g-suit. These functions create motion cues by determining and implementing linear and angular displacements and accelerations.

1.3 Document Overview. This segment specification defines Physical Cues segment unique requirements for the _____*(insert application aircraft type)* MSS. It contains requirements for the functions performed within the segment including communication interface requirements, segment performance requirements, segment diagnostic and test requirements, and expansibility and adaptability requirements as applicable to the Physical Cues segment.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

The Government documents which are applicable to the entire _____*(insert application aircraft type)* MSS are listed in Volume I of the system segment specification. The following Government documents are in addition to those documents and specifically applicable to the _____*(insert application aircraft type)* Physical Cues segment.

SPECIFICATIONS:

Federal - *(Identify applicable federal specifications)*
Military - *(Identify applicable military specifications)*
Other Government Agency - *(Identify applicable government specifications)*

STANDARDS:

Federal - *(Identify applicable federal standards)*
Military - *(Identify applicable military standards)*
Other Government Agency - *(Identify applicable government standards)*

DRAWINGS: *(Identify applicable drawings)*

OTHER PUBLICATIONS:

Manuals - *(Identify applicable manuals)*
Regulations - *(Identify applicable regulations)*
Handbooks -*(Identify applicable handbooks)*
Bulletins - *(Identify applicable bulletins)*

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting officer.

(In this paragraph list only those documents which are explicitly referenced within this specification volume. If a requirement paragraph is tailored to reference a system/segment specification Volume I paragraph, and that paragraph contains a reference, the document should not be listed here. All requirements and references in system/segment specification Volume I are requirements of this specification unless specifically excluded in this volume.)

2.2 Non-Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

The non-Government documents which are applicable to the entire _____ *(insert application aircraft type)* MSS are listed in Volume I of the system/segment specification. The following non-Government documents are in addition to those documents and specifically applicable to the _____ *(insert application aircraft type)* Physical Cues segment.

SPECIFICATIONS: *(Identify applicable non-government specifications)*
STANDARDS: *(Identify applicable non-government standards)*
DRAWINGS: *(Identify applicable non-government drawings)*
OTHER PUBLICATIONS: *(Identify applicable non-government publications)*

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies.

(In this paragraph list only those documents which are explicitly referenced within this specification volume. If a requirement paragraph is tailored to reference a system/segment specification Volume I paragraph, and that paragraph contains a reference, the secondary document should not be listed here. All requirements and references in system/segment specification Volume I are requirements of this specification unless specifically excluded in this volume.)

3. SEGMENT REQUIREMENTS

3.1 Segment Definition. The Physical Cues segment is one of _____ *(insert number of segments to be used in the application simulation)* unique segments which comprise the _____*(insert application aircraft type)* MSS. The Physical Cues segment shall provide the modes, states, and functions as defined in this specification volume and Volume I.

The Physical Cues segment shall provide the trainee with simulation of actual aircraft motion, g-forces (g-seat/g-suit) vibration and buffet and environmental sound cuing for the _____*(insert application aircraft type)* MSS.

(This paragraph should be tailored to convey the exact top level functions required of the segment. If this segment is to be used/reused on several devices within a family of trainers, that should be stated here with any unique performance requirements.)

3.2 Characteristics

3.2.1 Performance Characteristics. Performance of the Physical Cues segment shall be as specified herein and in accordance with the _____*(insert application aircraft type)* design criteria. The Physical Cues segment fidelity shall be sufficient to provide the trainee with the physical cues required for the necessary level of training as specified in Volume I, paragraph 6.1 of this specification.

(This statement should be modified to meet the contractual training requirements. Levels of fidelity should be specified in volume I.).

3.2.1.1 Segment Modes and States. The Physical Cues segment shall support the system modes and states as described in Volume I of this specification. Additional requirements, or operations specific to the Physical Cues segment shall not cause degradation of the system nor violate the intent of the system mode or state.

(Introduction of new modes is prohibited. New functions should be accomplished within the established modes and states. This paragraph should be tailored to describe the segment's specific response to a given mode or state. Subparagraphs should be added to identify and define unique segment requirements for each mode and state. An example would be that during reposition, the motion system must first settle and then ramp up to the new attitude.)

3.2.1.1.1 Total Freeze State. In this state, the Physical Cues segment shall cause the motion system/g-suit/g-seat to smoothly wash out to the neutral position and for the environmental sound function to wash out to a quiet condition.

(This paragraph should address the desired operation of the motion system/g-seat/g-suit and environmental sound functions during a total freeze state. Normally the sound function is turned

off during the total freeze state. This prevents a multiplicity of sounds emulating from the sound function as the various systems align themselves. Prevention of abrupt motion excursions, following a restart from total freeze, should also be addressed in this paragraph. Additional requirements for the motion system operation during the freeze state are covered in paragraph 3.3.6.4 of this volume)

3.2.1.1.2 Shutdown Mode. In this mode, the Physical Cues segment shall provide for a safe power down of the Physical Cues systems.

(In the shutdown mode, both normal and emergency, the Physical Cues segment shall cause the applicable motion system to wash out to the neutral position and then to the settled position and for the remaining physical cues functions to wash out to the null condition.

3.2.1.2 Physical Cues Segment Functions. The following functions shall be accomplished by the _____ *(insert application aircraft type)* MSS Physical Cues segment.

a. Physical Cues Support Function	Implemented
b. Environmental Sound Function	*(Implemented, N/A)*
c. G-suit Function	*(Implemented, N/A)*
d. G-seat Function	*(Implemented, N/A)*
e. Motion Function	*(Implemented, N/A)*
f. Vibration and Buffet	*(Implemented, N/A)*

(Each function listed should be characterized as "Implemented" or "Not Applicable (N/A)".)

3.2.1.2.1 Physical Cues Support Function. The Physical Cues support function shall provide the segment unique support services required for the operation of the Physical Cues segment in the MSS environment. The Physical Cues support function services shall include the functions listed below, and as described in the following paragraphs.

a. Executive Control
b. Initialization
c. MSS Virtual Network (VNET) Communication
d. Diagnostics and Test
e. Backdoor Interfacing
f. Malfunctions
g. Damage Assessment
h. Security Processing
i. Scoring
j. Other Support Function Services

(Service functions are usually incidental to the simulation, but no less critical. Examples are overhead and I/O functions. Additional services may be added as necessary to meet specific application requirements. If so, corresponding subparagraphs need to be added below. Do not reuse deleted paragraphs.)

3.2.1.2.1.1 Executive Control. The executive control support service shall provide operational control for the Physical Cues segment. This control shall include: execution sequencing of all software segments, mode and state control, and communication between the simulation software and the VNET.

(For most applications this paragraph will require no tailoring. If additional or specific executive control functions are required, they should be identified in this paragraph.)

3.2.1.2.1.2 Initialization. The initialization support service shall control initial hardware and software states for the Physical Cues segment. System initialization shall occur during power-up and system resets, as defined in Volume I of this specification. The initialization function shall also access mission initialization data, and transfer the data to other segment functions for mission initialization.

(Initialization requirements unique to the application aircraft Physical Cues segment should be specified in this paragraph. Initialization refers to setting initial hardware and software states during power-up and system resets as defined in Volume 1. Instrument scale factors and default instrument settings (usually powered off) are typically initialized by this function. A second initialization function is to access mission initialization data (for example from disc) to pass to other segment functions for mission initialization. Generally, all physical cues functions should initialize in a stable state.)

3.2.1.2.1.2.1 Environmental Sound Function. At simulator initialization, the environmental sound function shall initialize all environmental sounds to a silent condition.

(This paragraph should contain a list of initial condition requirements for each of the environmental sounds.)

3.2.1.2.1.2.2 G-suit Function. At simulator initialization, the g-suit function shall initialize the g-suit system to a condition indicative of one "g".

(This paragraph should contain a list of initial condition requirements for the g-suit.)

3.2.1.2.1.2.3 G-seat Function. At simulator initialization, the g-seat function shall initialize the g-seat to a condition indicative of one "g".

(This paragraph should contain a list of initial condition requirements for the g-seat)

3.2.1.2.1.2.4 Motion Function. At simulator initialization, the motion function shall be initialized to a condition indicative of no linear/angular displacements, velocities or accelerations present and in the fully settled position and not engaged.

(This paragraph should contain a list of initial condition requirements for the motion function.)

3.2.1.2.1.2.5 Vibration and Buffet Function. At simulator initialization, the vibration and buffet function shall be initialized to a condition indicative of no displacements, velocities or accelerations present.

(This paragraph should contain a list of initial condition requirements for the vibration and buffet function.)

3.2.1.2.1.3 MSS Virtual Network Communication. The MSS VNET communication support service shall provide the Physical Cues segment interface to the MSS VNET. It shall allow communication with other segments in the _____*(insert application aircraft type)* MSS. The Physical Cues segment shall communicate with the MSS VNET in accordance with the protocol requirements defined in the IDD _____ *(insert MSS IDD document number)*.

3.2.1.2.1.4 Diagnostics and Test. The diagnostics and test support service shall provide control for the diagnostic and test functions incorporated into the Physical Cues segment. Diagnostic and test requirements shall be in accordance with the requirements specified herein.

(Based upon the specific simulator diagnostic requirements, all or part of the three types of diagnostic capabilities may be required. "Not Applicable" should be inserted if the specific diagnostic type is not required for the application MSS. Specific diagnostics and their requirements should be listed in each paragraph when applicable.)

3.2.1.2.1.4.1 On-Line Diagnostics. On-line diagnostics shall be provided for the Physical Cues segment. These diagnostics shall be self initiating during start-up and/or as a background function during training mode.

(On-line Diagnostics are those diagnostics that are executed while the training system is in the real-time training mode. These diagnostics may run as a background task. An example that would be used in an MSS environment might be a segment functional diagnostic. Each segment would tell the IOS segment that it is still functioning on a periodic basis (say once a minute). If the IOS does not receive the message then it assumes the segment is not functioning properly and provides a message to the instructor.)

3.2.1.2.1.4.2 Off-Line Diagnostics. Off-line diagnostics shall be provided by the Physical Cues segment. Off-line diagnostics shall be executed, when the _____ *(insert application aircraft type)* MSS is not engaged in a training mode.

(Off-line Diagnostics are those diagnostics that are performed on a segment in the stand-alone or segment mode. Typical off-line diagnostics would include; hardware self tests, software tests, I/O debug programs, Daily Readiness at a segment level, etc.)

3.2.1.2.1.4.3 Remote Controlled Diagnostics. Remote Controlled Diagnostics shall be provided for the Physical Cues segment. These diagnostics shall be executed from the Instructor Operator Station (IOS) when the MSS is in the Remote Controlled Diagnostic mode.

(Remote Controlled Diagnostics are those diagnostics that run in the special remote controlled diagnostic mode. These diagnostics require the system to be up and running and the segments communicating. An example of a Remote Controlled Diagnostic would be a real-time debugger.)

3.2.1.2.1.5 Backdoor Interfacing. The backdoor interface support service shall provide the means to support external interfaces to the Physical Cues segment. All Physical Cues segment Input/Output (I/O) unless specifically identified in the _____*(insert application aircraft type)* MSS IDD shall interface via the MSS VNET. Backdoor interfaces shall not be utilized for normal intersegment communication.

(Specific backdoor external interfaces should be identified in this paragraph. Backdoor interfaces may include a 1553 bus to communicate with installed aircraft avionics or a specialized interface to drive a Heads Up Display (HUD). A backdoor interface may not be utilized to transmit intersegment data.)

3.2.1.2.1.6 Malfunctions. The malfunctions support service shall provide the control for the processing and execution of the Physical Cues segment malfunctions. The system response shall be in accordance with the aircraft design criteria.

(The Physical Cues segment malfunctions should be defined in a program unique Malfunction Description Document).

3.2.1.2.1.7 Damage Assessment. The damage assessment support service shall provide for the processing and implementation of any damage simulation for which the Physical Cues segment is responsible. This shall include the degradation of the appropriate systems within the Physical Cues segment based upon the evaluation of the damage severity and location.

(Based upon the training requirements of the application aircraft MSS, any specific damage assessment and system degradation requirements should be specified in this paragraph. i.e., a non-fatal hit by an other-ship weapon causing increased noise level.)

3.2.1.2.1.8 Security Processing. The Physical Cues segment security processing support service shall provide for the processing of the security requirements of the _____*(insert application aircraft type)* MSS Physical Cues segment.

(This paragraph should be expanded to clearly specify which government directives apply, and to what extent, consistent with security considerations. Security processing could include Memory Erase Mode if required and any other security considerations such as removable memory or special encoding devices.)

3.2.1.2.1.9 Scoring. The scoring support service shall provide the ability to collect specific data for the assessment of a student's performance in his utilization of the _____*(insert application aircraft type)* Physical Cues system. The Physical Cues segment scoring data shall be provided to the IOS segment via the MSS VNET.

(Application specific scoring data requirements for the Physical Cues segment shall be listed in this paragraph. If large amounts of data are required, it may be advisable to provide this to the IOS as a non-real-time activity.)

3.2.1.2.1.10 Other Support Function Services. Not Applicable.

(If there are other support functions unique to this segment they should be listed here, otherwise identify this paragraph as "Not Applicable". Intrasegment communication is an example of a function that might be listed in this paragraph. Before defining new functions, be sure the function cannot be incorporated as a variant of an existing function.)

3.2.1.2.2 Environmental Sound Function. The environmental sound function shall reproduce the aural cues at the simulated crew station which duplicate those heard in the actual aircraft crew station (i.e., frequencies and sound pressure levels).

The environmental sound pressures shall be adjustable, by the instructor, from the maximum that would be heard in the aircraft to zero.

The content and levels of the aural cues shall be dynamically controlled as a function of the interface defined in the _____*(insert application aircraft type)* MSS Interface Design Document (IDD).

(The following considerations should be addressed for the simulation of environmental sounds, based on training requirements:

a. *Ownship, tanker and companion engine and transmission sounds required (whines, efflux, roar, intake, etc.)*
b. *Airborne equipment sounds required to be audible in the MSS flight station*
c. *Landing gear sounds required to be audible in the MSS flight station (Landing gear extensions, retractions, impact,etc.)*
d. *Aerodynamic sounds required to be audible in the MSS flight station cockpit (high/low speeds, noise levels as a result of spoiler, flap and landing gear being extended).*

e. Equipment sounds from ground based equipment required to be audible in the MSS flight station (power, air carts, etc.).

f. Buffet and vibration sounds required to be audible in the MSS flight station cockpit (spoiler operation,landing gear extension/retraction, flaps operation, stalls, etc.).

g. In-flight refueling sounds required to be audible in the MSS flight station cockpit (tanker efflux, boom contact, lock, etc)

h. Weather sounds required to be audible in the MSS flight station cockpit (rain, hail, etc)

i. Ownship, companion and threat weapon sounds required to be audible in the MSS flight station cockpit (gun fire, missile launch, tank jettison, counter measures (flare, chaff) release)

j. Malfunction sounds required to be audible in the MSS flight station (compressor stalls, wheel burst,etc.)

3.2.1.2.3 G-Suit Function. The anti g-suit function shall provide the sustained "g" cues that would be experienced by pilots wearing an identical appearing and performing g-suit as in the _____ *(insert application aircraft type).*

"G" cue sensations shall be translated by this function from the Physical Cues input interface defined in the _____ *(insert application aircraft type)* MSS IDD. Aircraft accelerations shall be limited by the performance envelope of the _____ *(insert application aircraft type).*

(If a g-suit is required consideration must be given to the use of either an actual or a simulated g-suit. In most cases a look-like and functionally identical but simulated g-suit will be used by the _____ (insert application aircraft type) MSS. If the decision is made to incorporate a g-suit then either quantitative data or design criteria should be referenced here for the selected g-suit.)

3.2.1.2.4 G-Seat Function. The g-seat function shall provide motion cue sensations representative of those experienced by pilots of the _____ *(insert application aircraft type).*

Motion cue sensations shall be translated by the g-seat function from the Physical Cues segment input interface as defined in the IDD. The g-seat function shall provide timely and correlated motion cues representative of the _____ *(insert application aircraft type).*

(The primary consideration that should be addressed for the g-seat function is whether or not a g-seat is required. If a g-seat is required, design consideration must be given to functional and appearance characteristics of the g-seat which are required to support the training goals. These correlation requirements need to be specific and consistent with the system level cue correlation

and training requirements.)

3.2.1.2.5 Motion Function. The motion function, shall provide motion geometry, motion cues and motion base functions which together shall simulate the motion cues experienced by the aircrew of the _____ *(insert application aircraft type).*

The motion system shall perform smoothly and without hunting. Motion system movement shall be determined by computer computations based on six degrees of "aircraft" freedom. Motion system computations shall be executed at iteration rates sufficiently high to ensure that there will be no noticeable discrepancy between simulator motion cues and corresponding aircraft motion cues that would be experienced by trainees in response to the same flight control input in the actual aircraft. The frequency at which new motion cues occur shall be maximized. During motion platform position washout, new cues shall be accepted in any direction constrained only by the position and velocity limits of the system and the threshold of perception of the trainee. Spurious motion and washout shall at no time be noticeable to the trainee.

The motion function shall meet specific force and rotational accelerations, for each axis of movement, as measured at the neutral operating point.

(Normally linear acceleration is measured in "g's" and rotational accelerations are measured in deg/sec/sec.)

The _____ *(insert application aircraft type)* MSS motion system is an element in meeting the latency, timing and cue correlation performance requirements defined in Volume I of this specification.

(When specifying performance for a platform system, MIL-STD-1558 and FAA AC120-40A Phase II should be used as a guide. This standard was developed for, 6 Degree-Of-Freedom (DOF) systems, but contains fundamental requirements for any platform system. The degree to which the motion base function as an element in meeting the latency, timing, and cue correlation performance requirements should be explicitly defined here as a stand-alone requirement. It should be mentioned, however, that overall system performance is the overriding requirement.)

Aircraft linear and angular displacements and accelerations are translated by the motion geometry function to motion platform linear and angular displacements and accelerations.

Intersegment communication between the motion function and other physical cue segment functions will be at the discretion of the segment designer. However, all communication beyond the physical cues segment will be via the VNET, unless specifically identified as a backdoor interface.

(The following considerations should be addressed for the motion function:

a. *Level of motion geometry required (motion platform translational accelerations, rotational accelerations, velocities required , linear displacements, angular displacements as measured, at the neutral operating point of the motion platform)*
b. *Motion cues required (linear displacements, velocities, accelerations , angular displacement, and velocity, accelerations)*
c. *Motion base required (2 DOF, 3 DOF or 6 DOF, motion actuator positions, bandwidth, weight capacity and distribution, center of gravity, moments of inertia, platform dimension, floor loading and motion envelope)*

3.2.1.2.6 Vibration and Buffet Function. The vibration and buffet function shall be provided to generate vibration/buffet inputs to the _____ *(insert application aircraft type)* MSS g-seat and the MSS motion function. The system shall be under software control and shall be designed to generate vibration and buffet cues in accordance with design criteria.

Vibration and buffet cue characteristics shall be based on aircraft data, such as positions of control surfaces, doors and hatches, landing gear, engine and propulsion system vibration, tire and runway status, weapon and missile configuration and launch status. The performance characteristics for independent vibration and buffet actuation should include type and position of actuators, frequency and displacement range, etc. The flight station vibrations and buffets may be generalized using general purpose disturbance models which approximate the flight test data.

Control of vibration and buffet characteristics shall be computed as function of aircraft speed, control positions, flight conditions etc, in accordance with the supplied aircraft data.

(The following considerations should be addressed for the vibration and buffet function.

Motion cue vibration and buffet effects required to be felt by the student; (Threats, Stall Buffet, Mach Buffet, Flap/ Spoiler/Speed Brake Buffet, Control Surface Buffet, Runway Roughness - (snow, ice, standing water, surface roughness), Landing Gear Operation and Buffet, Nosewheel Scuffing, Landing Gear Impact, Thrust effect with brakes set, Gear bump after lift off, Weather Effects, etc.)

3.2.2 System Capability Relationships. The Physical Cues segment shall support the capability relationships defined in Volume I of this specification. Physical Cues segment functional relationships shall be as described in the following paragraphs.

(Define any Physical Cues segment unique capability relationships. In general, the capability relationships specified in Volume I will suffice for this segment.)

3.2.2.1 Segment Functional Relationships. The top level, typical, Physical Cues segment functional relationships are depicted in FIGURE 1. Each function shall operate in a manner which will allow the Physical Cues Segment, as a system, to satisfy the timing requirements described in Volume I of this specification. Functions implemented within the Physical Cues segment shall operate in such a manner that will allow the segment to meet both segment and system level requirements without degradation.

(There are two approaches to describing intra-segment interfaces: all functions communicate through the support function, or all functions communicate directly with other functions. FIGURE 1 in all segments should have the same structure. For this segment, functions which are not implemented should be shaded out. If desired, functions which are only partially implemented may be graphically represented with cross hatching. Note that the intent of this diagram should be to identify "required" internal relationships and not to specify the segments internal design. The tailoring of this paragraph should be done very carefully.)

3.2.3 External Interface Requirements. The Physical Cues segment shall support the external interface requirements defined in Volume I of this specification and the _____ *(insert application aircraft type)* MSS Interface Requirements Specification (IRS). External interfaces are comprised of data passed between Physical Cues segment functions and the functions contained in other MSS segments. With the exception of the dedicated interfaces for the cockpit, all other external interfaces which shall be used for the Physical Cues segment are specified in the MSS_____ *(insert application aircraft type)* IRS.

3.2.3.1 Facility Interface Requirements. The following air conditioning, chilled water, pneumatic air supply, and electrical power of the correct pressure, volume, temperature, voltage, wattage and frequency,etc., shall be provided.

a. Pneumatic Air Supply - _____ *(insert air volume and pressure requirements)*
b. Air Conditioning - _____ *(insert air volume, temperature and humidity minimum and maximum requirements)*
c. Floor Loadings - _____ lb/ft^2 *(insert floor loading requirements both point and total)*
d. Electrical Power - _____ *(insert all voltage, current, frequency requirements for the motion system.)*
e. Chilled Water - _____ *(insert hydraulic pump cooling water volume and temperature requirements)*
f. Facility Interlocks - _____ *(insert adequate design requirements to ensure that access to the motion platform and envelope area are protected from inadvertent personnel access during periods of motion system operation.)*

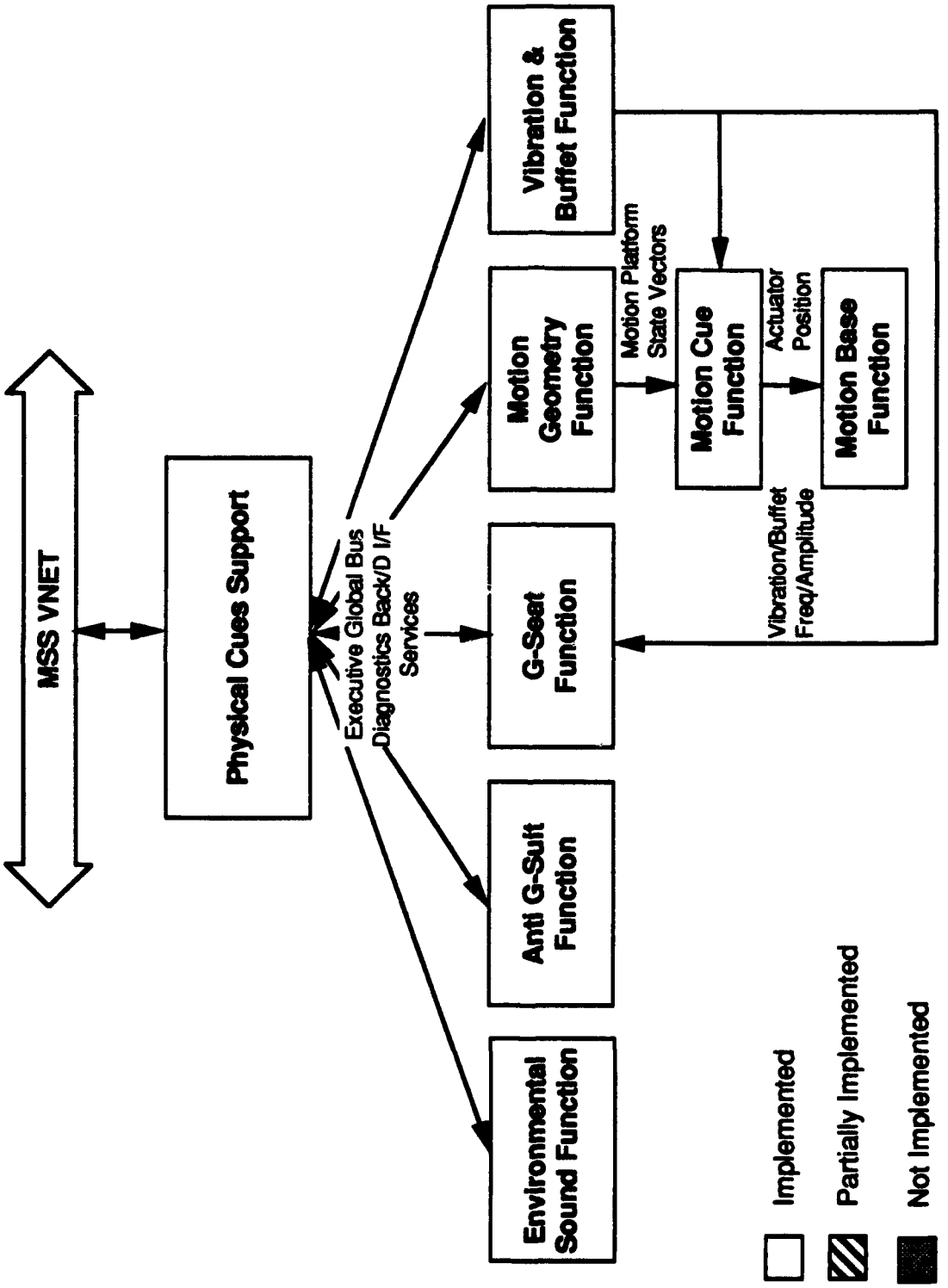

FIGURE 1 PHYSICAL CUES SEGMENT FUNCTIONAL RELATIONSHIPS

(Physical Cues segment unique external interface requirements for primary power, cooling, floor space, etc., should be identified here or referenced back to Volume I. Also who, customer or vendor, is responsible for suppling each power source should be specified in this paragraph)

3.2.4 Physical Characteristics. The physical characteristics of the Physical Cues segment shall meet the requirements as specified in Volume I of this specification. The Physical Cues segment physical characteristics shall be of such design as to interface with the other MSS segments via the MSS VNET.

(Physical characteristics requirements for the Physical Cues segment, other than those provided by the Physical Cues segment computational system and its interface to the MSS VNET shall be defined in this paragraph. Physical characteristic requirements may include backdoor interface hardware to connect Physical Cues segment (I/O) to the application aircraft cockpit. In addition, any weight or size considerations applicable to the Physical Cues segment should be considered.)

3.2.4.1 Protective Coatings. Physical Cues segment protective coatings shall be as defined in Volume I of this specification.

(Additional protective coating requirements which are required for the Physical Cues segment may be defined in this paragraph. In general, the requirements of Volume I should suffice for the entire system.)

3.2.4.2 Environmental Sound Function. The physical characteristic requirements for the environmental sound function shall include, in addition to that provided by the Physical Cues segment computational system and its interface to the MSS VNET, speakers, audio amplifiers and sound pressure level control. The cockpit speaker position, size and external connection shall be capable of a high fidelity reproduction of the cockpit sounds representative of the aircraft. The trainees' headset shall not be used to reproduce the simulated sounds.

Generally environmental sound function systems are commercial off-the-shelf and the only unique requirements would be the interface requirements.

3.2.4.3 G-Suit Function. The physical characteristic requirements for the g-suit shall include, in addition to that provided by the Physical Cues segment computational system and its interface to the MSS VNET, the physical hardware interface to the g-suit and corresponding air supply.

The g-suit function shall provide an g pressure schedule representative of that in the actual aircraft with a pressure range from _____ psi to a maximum of _____ psi. Fail-safe means shall be provided to prevent pressurization above the specified maximum. The "pressure onset" (g-intercept at zero psi) shall be variable from at least _____ to _____ "g's". The "slope(s)" of the pressure curve (psi/g) shall be adjustable from

at least _____ to _____ psi/g. During a simulator "freeze" condition, the g-suit shall be pressurized to that level corresponding to the one-g state.

The g-suit function control system shall provide proportional control of the steady-state suit pressure as a function of aircraft normal acceleration. The constant of proportionality shall be within _____ percent of the specified slope. Suit pressurization for the simulated "g" level less than or equal to the selected "pressure onset" value, shall not deviate from zero by more than _____ psi.

The g-suit shall respond to a full range commanded step change in pressurization by reaching _____ percent *(normally 63 percent)* of its final value within _____ second for inflation and _____ seconds for exhaust.

(If an actual aircraft g-suit is to be used in the MSS cockpit care must be exercised to provide suit inflation air pressures that correspond to those pressures that would be expected in the aircraft. If a simulated g-suit is to be used care must be exercised to specify a suit that replicates the aircraft g-suit in appearance and functionality. Air pressures must be supplied that will generate the same physical cues exerted on the trainee that would be felt in the aircraft under the same circumstances.)

3.2.4.4 G-Seat Function. The g-seat shall be a replica of the actual aircraft seat and capable of being collocated in the training device cockpit. Power requirements for this function shall be as specified herein.

(When specifying g-seat requirements care must be exercised to not eliminate certain seats by overly restrictive requirements. However, number of seat bladders, air pressure requirements, seat shaker requirements and other hardware requirements should be specified in this paragraph.)

3.2.4.5 Motion Function. The physical characteristics for the _____ *(insert application aircraft type) MSS* motion base function shall include all physical equipment requirements associated with the _____*(identify 2 DOF, 3 DOF or 6 DOF)* motion system. The motion system equipment shall include the platform and its various components (hydraulic pump, motion control cabinet, etc.), the hardware interfaces to the computational system and facility.

The motion function shall meet frequency range _____ *(measured in hertz)*, maximum phase shift _____*(measured in degrees)* and maximum attenuation _____*(measured in decibels)* closed-loop response in _____ *(insert number of axes)*.

The transient response shall be measured from the onset of the command input to the onset of the motion platform response.

Transient response shall be consistent with system timing, latency and cue correlation requirements of Volume 1.

The motion base shall be capable of responding to vibrations of at least _____ *(insert g value, typically 0.25g)* up to ____ Hz *(insert frequency requirement, typically 10 Hz)* and detectable vibrations to at least ___ Hz *(insert frequency requirement, typically 30 Hz)*.

The nominal payload of the motion platform will consist of crew station and occupant(s) weight, center of gravity (CG), and moments of inertia + _____ % *(insert weight growth projections)* for growth

The physical characteristics for the _____ *(insert application aircraft type)* MSS motion function shall include:

a. Degrees of Freedom - _____ *(2 DOF, 3 DOF or 6 DOF)*.
b. Frequency Response - _____ *(provide amplitude/ frequency response curve)* (A typical 6 DOF motion system has a closed loop performance. In addition, motion systems are typically designed to not have resonant frequencies below 5 Hz. This characteristic enhances the dynamic controllability of the motion system. A motion system should also have a response to a step input within 0.05 second.)
c. Angular Measurements:
   Angular Displacement - +/-_____ deg.
   Angular Velocity - +/-_____ deg/sec
   Angular Acceleration - +/-_____ deg/sec^2
d. Linear Measurements:
   Linear Displacement - +/-_____ ft. *(This measurement will be less than the total extension length of each actuator, this will allow for hydraulic cushions at both ends of the actuators to absorb excess energy.)*
   Linear Velocities - +/-_____ ft/sec
   Linear Accelerations - +/-_____ ft/sec^2
e. Payload requirements:
   Weight Capacity - The motion system shall be capable of withstanding a load of ___times the rated load under simultaneous conditions of worst case configuration and worst case dynamic loads.
   Weight Distribution - The motion function of the _____ *(insert application aircraft type)* MSS shall meet the above requirements for any center of gravity within +/- inches of nominal.
   Moment of Inertia - _____ slug ft^2
   Platform Dimensions - _____ ft.
   Motion Envelope - _____ *(as measured at the extremes of flight station cabin excursions)*

(This paragraph is used to specify a platform based motion system. Generally platform systems are commercial off-the-shelf and the only unique requirements would be the interface requirements. Specifying a platform system involves increased facility costs above and beyond the system cost.)

3.2.4.6 Vibration and Buffet Function. The physical characteristics of the vibration and buffet features for the motion function shall be provided by the Physical Cues segment computational system, its interfaces to the MSS VNET and physical equipment associated with the vibration and buffet function. The vibration and buffet function equipment shall include actuation hardware, interface to the computational system and provision of primary power for the actuators if independent actuation is required.

The motion function shall provide vibration and buffet special effects and determine the content and magnitude of simulated _____ *(insert application aircraft type)* vibration and buffet motion cue effects. The motion function shall be capable of producing vibrations and buffets of at least _____ *(insert g value, typically 0.25g)* up to _____ Hz *(insert frequency requirement, typically 10 Hz)*and detectable vibrations to at least ___ Hz *(insert frequency requirement, typically 30 Hz)*. These motion cue effects duplicate those cues felt by pilot's in the _____ *(insert application aircraft type)*.

The simulated _____ *(insert application aircraft type)* MSS aircraft seat shall be capable of vibration excursion up to +/- _____ inches *(insert excursion requirements)* parallel to the normal body axis of the MSS aircraft. The frequency spectrum between _____ and _____ Hz shall be within _____ percent of the approved data. The amplitude and frequency shall be continuously variable over the specified ranges and shall be controlled by the software to allow for non-linear response and ease of software modification. The system shall be designed to prevent application of specific forces in excess of 2"g".

Generally platform systems are commercial off-the-shelf and as such have vibration and buffet functions as an integral function of the motion system; therefore, only unique requirements would be the interface requirements. If a crew member seat is to be used to generate vibration and motion cues, then specific characteristics of that seat should be specified in this paragraph

3.2.5 Physical Cues Segment Quality Factors

3.2.5.1 Reliability. The system level reliability requirements applicable to all segments in the MSS are defined in Volume I of this specification. The Physical Cues segment reliability must be _____ % to satisfy the system level reliability requirements. The Mean Time Between Critical Failure (MTBCF) shall not be less than _____ hrs.

(A specific allocation of reliability (e.g. MTBCF) for this segment should be specified in this paragraph. Reliability should be allocated to each segment in such a way that system level reliability requirements will be met. Normally this means that segment reliability will be higher than system reliability.)

3.2.5.2 Maintainability. The system level maintainability requirements applicable to all segments in the MSS are defined in Volume I of this specification. The Physical Cues segment shall have a mean corrective maintenance time, of ____ minutes, and a 90th percentile maximum corrective maintenance time of ____ minutes to satisfy the system level maintainability requirements.

(Maintainability requirements such as Mean Time to Repair (MTTR) should be allocated to each segment in such a way that system level maintainability requirements will be met. Normally this means that segment MTTR will be less than system MTTR. System level requirements will include isolation to a faulty segment.)

3.2.5.3 Availability. The system level availability requirements applicable to all segments in the MSS are defined in Volume I of this specification.

(Usually, availability applies only to the system level. Reliability and Maintainability (MTBF and MTTR) should be allocated to each segment in such a way that system availability requirements will be met. It would be unusual to impose an availability requirement at the segment level.)

3.2.5.4 Additional Quality Factors. The additional quality factors, as defined in Volume I of this specification, shall apply to Physical Cues segment.

(The additional Physical Cues segment unique quality factors may be defined in this paragraph. In general, the system level additional quality factors will suffice for the Physical Cues segment.)

3.2.6 Environmental Conditions. The environmental conditions requirements, as defined in Volume I of this specification, shall apply to Physical Cues segment.

(Identify any Physical Cues segment unique environmental requirements. In general, the system level environmental conditions will suffice for the Physical Cues segment.)

3.2.7 Transportability. The transportability requirements, as defined in Volume I of this specification, shall apply to Physical Cues segment.

(Identify any Physical Cues segment unique transportation requirements. There may exist unique transportation requirements to ship the segment from the segment contractors facility to the prime contractors facility. In general, the system level transportability requirements will suffice for the Physical Cues segment.)

3.2.8 Flexibility and Expansion. The flexibility and expansion requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Unique requirements for this segment may include spare memory, spare time, spare mass storage, I/O channels by type, chassis expansion slots, etc. Expansion requirements should consider the likelihood this segment will need to change as well as the cost of including capability now versus cost to change later. Reuse of the segment in future applications should also be considered and specified.)

3.2.9 Portability. The portability requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Except for field transportable trainers portability of hardware is usually not a requirement. Portability of software may be a concern of future changes which may include upgrading the Computer Hardware Configuration Item (HWCI) are considered likely. Use of a standard higher order language such as Ada is usually adequate to assure software portability.)

3.3 Design and Construction. The design and construction requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique design and construction requirements. Normally most components that would make up the Physical Cues segment (i.e., audio components, motion systems and etc.) will be provided as commercial-off-the-shelf components and, as such, best commercial standards would apply. In general, the system level design and construction requirements will suffice for the Physical Cues segment.)

3.3.1 Materials. The materials requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique materials requirements. Normally most components that would make up the Physical Cues segment (i.e., audio components, motion systems and etc.) will be provided as commercial-off-the-shelf components and, as such, best commercial standards would apply. In general, the system level materials requirements will suffice for the Physical Cues segment.)

3.3.1.1 Toxic Materials. The toxic materials requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique toxic materials requirements, (i.e. hydraulic fluid). In general, the system level toxic materials requirements will suffice for the Physical Cues segment.)

3.3.2 Electromagnetic Radiation. The electromagnetic radiation requirements, defined in Volume I of this specification, shall

apply to the Physical Cues segment.

(Identify any Physical Cues segment unique electromagnetic radiation requirements. In general, the system level electromagnetic radiation requirements will suffice for the Physical Cues segment.)

3.3.3 Nameplates and Product Marking. The nameplate and product marking requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique nameplate and product marking requirements. In general, the system level nameplate and product marking requirements will suffice for the Physical Cues segment.)

3.3.4 Workmanship. The workmanship requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique workmanship requirements. In general, the system level workmanship requirements will suffice for the Physical Cues segment.)

3.3.5 Interchangeability. The interchangeability requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique interchangeability requirements. In general, the system level interchangeability requirements will suffice for the Physical Cues segment.)

3.3.6 Safety. The safety requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

A physical cues segment safety system shall be provided by a full range of electrical, hydraulic and mechanical devices, as required to prevent injury to the MSS users.

(Because of the nature of the Physical Cues Segment, safety is an important issue and must be addressed in this paragraph. Safety issues, such as, hazardous noise levels, safety barricades around the motion base and g-Seat/g-Suit operating limits should be considered.

3.3.6.1 Environmental Sound Function. The sound pressure level controlled by the environmental sound function shall not exceed _____ dB *(insert maximum sound intensity, normally 100 db, and frequency levels, normally 63 Hz to 8000 Hz)* as measured at all trainee station positions.

The exposure time limit shall be determined from the following equation.

$$T = \frac{16}{2^{(L-80)/4}}$$

where T = Total daily exposure limit in hours
L = Noise level in dBA

Exposure time in all areas of instructor and trainee stations shall be held below the values calculated above.

The noise level at student and instructor station(s) shall not exceed an articulation index (AI) of 0.7, where the AI is determined by the octave band method. An exception may be granted to this requirement if the sounds reflecting actual aircraft audio conditions exceed the above requirement. In these cases the time limit valves imposed by the equation above shall not be exceeded.

(ANSI Standard S3.5 Methods for Calculation of the Articulation Index should be used as a guide in setting requirements and computing the articulation index. If the application aircraft MSS has an on-board instructor station the identical sound level requirements will be placed on the instructor position. MIL-STD-882 contains health and safety hazard information concerning sound levels. If this is not covered in Volume I, it should be addressed here.)

3.3.6.2 G-Suit Function. As a minimum the following safety features will be a part of the design for the _____ *(insert application aircraft type)* MSS g-suit function.

(G-suit safety considerations, if any, should be addressed here or in Volume 1.

The g-suit is used in the aircraft to protect the crew from short bursts of high "g's" during combat which may last 2 or 3 minutes. In the trainer the same maneuver may be repeated many times over during a training session. Sustained g-suit pressures could cause physical injury such as contusions. Consideration must be given to wash-out or limiting the g-suit response to g-loads.)

3.3.6.3 G-Seat Function. As a minimum the following safety features will be a part of the design for the _____ *(insert application aircraft type)* MSS g-seat function.

(G-seat safety considerations, i.e. seat belt shear pins, should be addressed here or in Volume 1.)

3.3.6.4 Motion Function. As a minimum the following safety features will be a part of the design for the _____ *(insert*

application aircraft type) MSS motion function.

a. Door Interlocks - A door interlock switch shall be provided for the flight station door. The flight station door must be closed before motion can be engaged. Opening of this door during motion system operation shall cause the motion platform to return smoothly to the fully down and level position.
b. Drawbridge Interlocks - A powered access drawbridge or ramp must be removed from the operating envelope of the motion system before the system can be activated. To ensure that a collision between the drawbridge/ramp and the motion platform is avoided, drawbridge/ramp interlock switches will be utilized. In the event of an emergency shutdown, an automatic drawbridge/ramp extension shall be provided once the motion system has settled in the level access position.
c. Entry Gate Interlocks - Interlock switches shall be fitted to entry gates in the motion envelope safety barrier. *(This safety barrier may in some cases be provided by the customer)* All entry gate interlocks must be closed before the motion system can be engaged. Opening any gate during motion system operation will return the platform to rest at the fully down and level position.
d. Walkway - An exterior walkway shall be provided on the motion platform and will be fitted with a handrail.
e. Escape Ladder - A fire resistant escape ladder/rope shall be located within easy reach of the flight station access door to provide an emergency means of descent.
f. Hydraulic Cushions - Hydraulic cushions shall be provided over the last _____ inches of actuator travel at both ends. These cushions shall be capable of absorbing gently and safely maximum energy produced by the actuators.
g. Overtravel Limiters - Electro-mechanical switches shall be installed on each actuator and will terminate motion operation whenever the actuator has entered a hydraulic cushion area.
h. Emergency Settling - The motion system shall be capable of automatically settling should the motion system lose hydraulic pressure, electrical power, violation of any limit switch or the operation of any emergency stop.
i. Emergency Switches - The following emergency switches will be provided, as appropriate, motion safety switch, hydraulic safety switch, emergency hydraulic stop, emergency simulator stop, control loading/motion interlock and hydraulic warning switches.
j. Hydraulic Warning Switches - The following hydraulic warning switches will be supplied and so designed so as to cause an emergency shut-down of the motion system; hydraulic fluid over-temperature switch, hydraulic

fluid over-pressure switch, and hydraulic fluid low level.

At no time shall the motion system move unexpectedly. "Freezing" or release from a simulator computer "freeze" condition shall not result in rapid motion system movement, even if flight control inputs have been made during the "freeze" state. Further, engaging the motion system shall result in a non-rapid low velocity transition from the settled position to the normal operating position in less than ____ seconds. Other computer-controlled changes in motion system position such as transition to initial conditions, automatic demonstration modes, etc., shall not be rapid. A rapid motion simulator movement shall be defined as any movement which imparts an acceleration greater than ____ g to the occupant.

Disengagement of the motion system shall not result in abrupt motion system movement. Abrupt motion system movement shall not occur when power subsystem components are deactivated unexpectedly, nor if line power failure or fluctuation occurs. An abrupt system movement shall be defined as any movement which imparts an acceleration greater than _____ g to the occupant.

3.3.6.5 Vibration and Buffet Function. The vibration and buffet shall provide to the instructor a means by which the vibration and buffet function may be turned off/on. The function shall also provide a means by which the instructor may readily control the amplitude profile of the system. An interlock shall be provided to insure that the seat belt is secured prior to the system being turned on.

(Any unique safety considerations applicable to the vibration and buffet function (i.e., seat belt shear pins) should be specified in this paragraph)

3.3.7 Human Engineering. The human engineering requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique human engineering requirements. In general, the system level human engineering requirements will suffice for the Physical Cues segment.)

3.3.8 Nuclear Control. The nuclear control requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique nuclear control requirements. In general, the system level nuclear control requirements will suffice for the Physical Cues segment.)

3.3.9 System Security. The system security requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique system security requirements. In general, the system level system security requirements will suffice for the Physical Cues segment.)

3.3.10 Government Furnished Property. Government Furnished Property (GFP) shall be as identified in Volume I of this specification.

(Identify any Physical Cues segment unique GFP requirements. In general, the system level GFP requirements will suffice for the Physical Cues segment.)

3.3.11 Computer Resource Reserve Capacity. The system level reserve capacity requirements applicable to all segments in the MSS are defined in Volume I of this specification.

(In addition to the computer resource reserve capacity identified in Volume I, the specific reserve capacity for the Physical Cues segment may include the computational system hardware and software required to design, develop, and test the Physical Cues segment. System considerations such as spare (time, memory, storage, I/O channels) for growth unique to this segment should be imposed here. If this paragraph requires subparagraphs they should follow the numbering and topics used in Volume I.)

3.4 Documentation. The documentation requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique documentation requirements. Documentation requirements for the Physical Cues segment may include vendor documentation, interface specifications and design data for interfacing to an embedded piece of cockpit equipment (i.e. a g-suit.))

3.5 Logistics. The system level logistics requirements for the Physical Cues segment shall be as specified in Volume I of this specification, paragraph 3.5, and all subparagraphs of paragraph 3.5.

(Unique support requirements for this segment should be described here. These may include special tools and jigs for installation, alignment and calibration; special environmental conditions for operation and repair such as a clean-room for component repairs; levels and types of spares required.)

3.6 Personnel and Training. The system level personnel and training requirements, defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Identify any Physical Cues segment unique personnel and training requirements (i.e., motion system, g-suit, g-seat maintenance training and the required maintenance manuals). In general, the system level personnel and training requirements (number, skills and training for

maintenance personnel.) will suffice for the Physical Cues segment.)

3.7 Subordinate Element Characteristics. Not Applicable.

(This volume defines requirements for a subordinate element of the MSS. In general, there will be no subordinate elements of a segment.)

3.8 Precedence. The precedence requirements for the Physical Cues segment shall be as specified in Volume I of this specification.

4. QUALIFICATION REQUIREMENTS

4.1 Responsibility For Test and Inspection. The _____*(insert application aircraft type)* MSS responsibility for test and inspection requirements are defined in Volume I of this specification. The requirements defined in Volume I shall apply to the Physical Cues segment.

(This paragraph may be tailored to identify additional test or inspection requirements which are specific to the Physical Cues segment.)

4.2 Special Tests and Examinations. The system level general qualification events, levels, and methods of testing for the Physical Cues segment are defined in Volume I of this specification. The requirements defined in Volume I shall apply to the Physical Cues segment.

(Clearly identify which test events defined in Volume I apply to this segment. Be particularly explicit about the segment builder's responsibility during system integration and test. In some cases, verification can only be achieved in the integrated mode. A clear definition of the segment supplier's responsibility during systems integration should be contained in the SOW.

This paragraph may be tailored to identify additional test or inspection requirements which are specific to the Physical Cues segment. The following list contains examples of special tests that may be required depending on the application aircraft specific verification requirements.

a. *Integrated Flight Control, Physical Cues and Visual Segments Latency and Cue Correlation Tests - Although thorough and complete design data will reduce the amount of tuning and testing that may be required, a test to confirm proper latency and cue correlation of the Flight Control, Physical Cues and Visual Segments may still be required.*
b. *Autotests - These tests are initiated from the IOS for the purpose of segment cue correlation and latency testing. Autotest provides repeatable results in a much shorter period of time than pilot in the loop tests. This may be for acceptance testing or simulator certification. The types and extent of test to be included will be driven by the support concept and availability requirements of the system and their allocation to this segment. Autotest may be used for acceptance by the procurement agency and certification by the user or FAA (SIMCERT/AC120-40).*
c. *Audio Tests - Qualitative tests shall be conducted to evaluate the accuracy of the audio sound generated by the environmental sound function relative to location, frequency and amplitude.*
d. *Motion tests - Quantitative tests shall be conducted to verify the performance requirements of the motion tests. These tests shall include as a minimum step response, excursions and velocities, frequency response, damping, smoothness, static accuracy , crosstalk, stability, etc. Several motion system requirements may be verified by inspection of the system. These test may include safety provisions,*

personnel access provisions, acoustic noise in maintenance areas, etc.

Responsibility for integrated tests should be minimized at the segment level. If the segment is required to pass an integrated test, as part of its acceptance, that test(s) should be called out here. Additional tests might include segment compliance tests which can only be performed with the segment installed as part of a system. These should be identified here and the requirements detailed by adding subparagraphs.)

4.3 Requirements Cross Reference. A requirements compliance cross reference matrix shall be developed to ensure requirement traceability. The requirements cross reference matrix shall be included as part of the _____ MSS Prime Item Development Specification (PIDS).

5. PREPARATION FOR DELIVERY. The _____*(insert application aircraft type)* MSS preparation for delivery requirements, as defined in Volume I of this specification, shall apply to the Physical Cues segment.

(Segment unique requirements may include packaging the segment for shipment to the integration location which could be different than packaging the system for shipment to the installation site. If requirements are imposed here, there may be test requirements for verification which must be added to Section 4.)

6. NOTES

6.1 Intended Use. The _____ *(insert application aircraft type)* MSS shall be used as an integral part of the _____ *(insert application aircraft type)* aircraft training system.

6.1.1 Missions. The Physical Cues segment shall support the mission requirements, as described in paragraph 6.1.1 of Volume I of this specification. It shall provide the Physical Cues portion of training required for cockpit familiarization, flight characteristics, operating procedures, and mission procedures for the _____*(insert application aircraft type)* MSS. The Physical Cues simulation shall assist in allowing the trainee to become familiar with the cockpit configuration and flight characteristics of the aircraft, gain proficiency in executing normal procedures, in recognizing malfunctions/abnormal indications and executing the corresponding emergency procedures, and in executing mission procedures. Normal procedures and emergency procedures specified herein shall be taken from the aircraft Technical Orders (T.O.s) for the application aircraft. The trainees may range in experience from newly designated aviators undergoing initial training to experienced aviators undergoing refresher training.

(The Physical Cues segment mission is to support the trainer mission as described in Volume I. Any mission specific information should be described in this section. An example would be a segment intended to support a family of trainers such as a procedures trainer, part-task trainer, flight trainer, or weapons system trainer.)

6.1.2 Threat. Not applicable.

(This paragraph shall describe the threat which the system is intended to neutralize. In this context, this paragraph is not applicable to most simulators, and will generally remain "Not applicable".)

6.2 Physical Cues Segment Acronyms. The acronyms contained in this paragraph are unique to the Physical Cues segment and are in addition to the MSS acronyms contained in Volume I of this specification, paragraph 6.2.

AI	Articulation Index
CG	Center of Gravity
DB	Decibel
DOD	Department of Defense
DOF	Degree of Freedom
FT	Feet/Foot
GFP	Government Furnished Property

HZ	Hertz
IDD	Interface Design Document
IOS	Instructor Operator Station
I/O	Input/Output
IRS	Interface Requirements Specification
LB	Pound
MSS	Modular Simulator System
MTBCF	Mean Time Between Critical Failure
N/A	Not Applicable
PIDS	Prime Item Development Specification
PSI	Pounds Per Square Inch
T.O.s	Technical Orders
VNET	Virtual Network

6.3 Glossary of Physical Cues Segment Terms. The terms contained in this paragraph are unique to the Physical Cues segment and are in addition to the MSS terms contained in Volume I of this specification, paragraph 6.3.

ANGULAR ACCELERATION - A motion cue intended to produce the sensation of a change in the attitude of the ownship, i.e., a change in pitch, roll, or yaw.

ANGULAR DISPLACEMENT - The difference in position of a motion base from its neutral central point around an angle, expressed as either pitch, roll, or yaw.

AURAL CUES - Sounds perceived in the cockpit which emanate as a by product of the function of aircraft and external equipment and directly by the environment. Examples could include thunder, explosions, wind noise and engine sounds.

BUFFET - A low frequency, high magnitude physical effect on an aircraft resulting from flight through an atmosphere or malfunction of certain types of aircraft equipment.

ENVIRONMENTAL SOUND - A set of audio cues which include: (a) engine transmission sounds, (b) landing gear sounds, (c) aerodynamic sounds, (d) equipment noises, (e) buffet and vibration sounds, (f) inflight refueling sounds, (g) weather sounds, and (h) weapon sounds including those associated with the ownship, companions and threats.

G-Forces - The sum of the forces acting on an object as a result of change of motion of the object and gravity. A body at rest, or in uniform motion, would experience only 1g. Dynamic forces may add or subtract from gravitational force and result in more than 1g, less than 1g, zero g, or negative g.

G-SEAT - A simulated aircraft seat to provide motion cues by the direct stimulation of somatic sensory system of trainee.

G-SUIT - A suit capable of rapidly changing the pressure on a pilot's body so as to counteract the effects of g-forces encountered in aircraft flight. Such devices typically consist of a bladder which surrounds the trainee's body.

LINEAR ACCELERATION - A motion sue intended to produce the sensation of a change in the velocity of the ownship, i.e. a change in up/down, left/right or forward/back.

LINEAR DISPLACEMENT - The difference in position of a motion base from its neutral central point along a straight line, expressed as either up/down, left/right or forward/back.

MOTION - The act or process of changing position, either (1) the aircraft's position or (2) the Air Vehicle Training Systems device (e.g. via a motion base). A system for moving a platform in sympathy with aircraft linear and angular accelerations etc.

MOTION BASE - An external component related to the Physical Cues Segment, consisting of equipment for the actual movement of the trainee station in space in terms of its linear and angular displacements. The intent of such devices is to produce the sensation of actual aircraft flight.

MOTION CUE - Any physical cue intended to produce a sensation of aircraft flight. Examples include pitch up/down of the motion base, the addition of pressure through a G-Suit, and so forth.

MOTION GEOMETRY - the mapping of a simulated flight path to the displacement and acceleration limitations of a motion base. Simulation of aircraft motion requires such a map because motion bases are not capable of the same range of movement as an actual aircraft in flight.

PHYSICAL CUES - The simulation of the motion and environmental sound cueing for the application aircraft. Examples include movement of a motion base, detonation-like noises, etc.

PHYSICAL SENSATION -The result within or on a trainee's body of a physical cue. An example is the sensation of falling forward, resulting from a tilt forward and down by a motion base.

SOUND GENERATION EQUIPMENT - Any equipment associated with the Air Vehicle Training System device which enables the creation of sounds audible to the trainee.

TRAINEE PERCEPTION - The deduction that a trainee would most likely make about his situation in response to a physical sensation. For example, a falling physical sensation would most likely lead the trainee to deduce that the aircraft is diving.

VIBRATION - A frequency, low magnitude physical effect on an aircraft resulting from flight through an atmosphere or malfunction of certain types of aircraft equipment.

VISUAL CUES - Any physical cue which the trainee can see. Examples include reproduction of cockpit appearance and dynamic out-of-the-window displays.

WARNING TONES - Audible sounds indicating a dangerous or abnormal situation. Example include engine fire bells, stall warnings, etc.

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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	BMAC-STS-86-303-1 Total revision required to incorporate changes required by testing/validation efforts and Government comments.	91/01/11 91/01/11 91/01/14 91/01/11 91/01/15	L. Clem Prepared By Checked By Dwg. Qual. Supervised By Approved By
B	CCP HSV-H91-008 Total revision required to incorporate changes resulting from addition of two new specifications and new functional allocation. Damage Assessment and Scoring were added to the module support function.	91/06/26 91/06/26 91/06/26 91/06/27 91/06/27	L. Stucky Jr. Prepared By Checked By Dwg. Qual. Supervised By Approved By

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REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL
C	CCP HSV-H91-008 Total revision required to incorporate Government comment on document.	91-09-26	K. Kelly Prepared By
		91-09-26	Checked By
		91/09/26	Dwg. Qual.
		91-09-26	Supervised By
		91-10-08	Approved By
D	CCP HSV-H91-017 This specification volume has been totally revised to: 1. Change the format to comply with DI-CMAN-80008A. 2. Incorporate the tailoring instructions into the body of the text. The incorporation of tailoring instructions into each specification volume has caused a change in the number of specification volumes from fourteen to thirteen. Prior to this change, all tailoring instructions were provided in Volume XIII and Volume XIV contained the Tactical and Natural Environment segment specification. The content of Volume XIII has been integrated into the other specification volumes. The change is summarized as follows: **Volume** **IS** **WAS** I through XII Titles for these volumes are unchanged XIII Environment Tailoring Instructions XIV "Deleted" Tactical and Natural Environment	93-08-23	PREPARED
		93-08-23	CHECKED
		93-08-23	SUPERVISED
		93/08/24	APPROVED

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